

Creating affordable efficiency – Low Income Multifamily housing



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Project partners



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An EDISON INTERNATIONAL Company

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Project Overview and Goal

- Funded through CEC PIER along with SCG and SCE ET funding
- Identify energy efficiency technology packages
- Test and monitor impact of measures
- Evaluate economic feasibility of measures
- **Total project value of \$2.9M**



Evaluating optimal technology and business models to scale deep energy efficiency retrofits in low income multifamily housing



LINC Housing

- 501(c)(3) Corporation founded in 1984
- Fifty-seven properties statewide with approximately 5,500 units
- New development has been received LEED for Homes Platinum certification
- Resident Services has successfully integrated sustainability education into resident programming



Project Approach

Step 1: Building Calibration and Custom Measures

- Physical audits informed models
- Data release from SCE
- E+ models calibrated with audits for gas and electric

Step 2: Develop Technology Packages

- Develop whole building EE packages using models
- Perturbation analysis for energy and cost to select measure package

Step 3: Contract and Construct

- Develop scopes of work, identify construction manager and bid construction contracts
- Develop rigorous test-in and test-out procedures and enforce with contractors

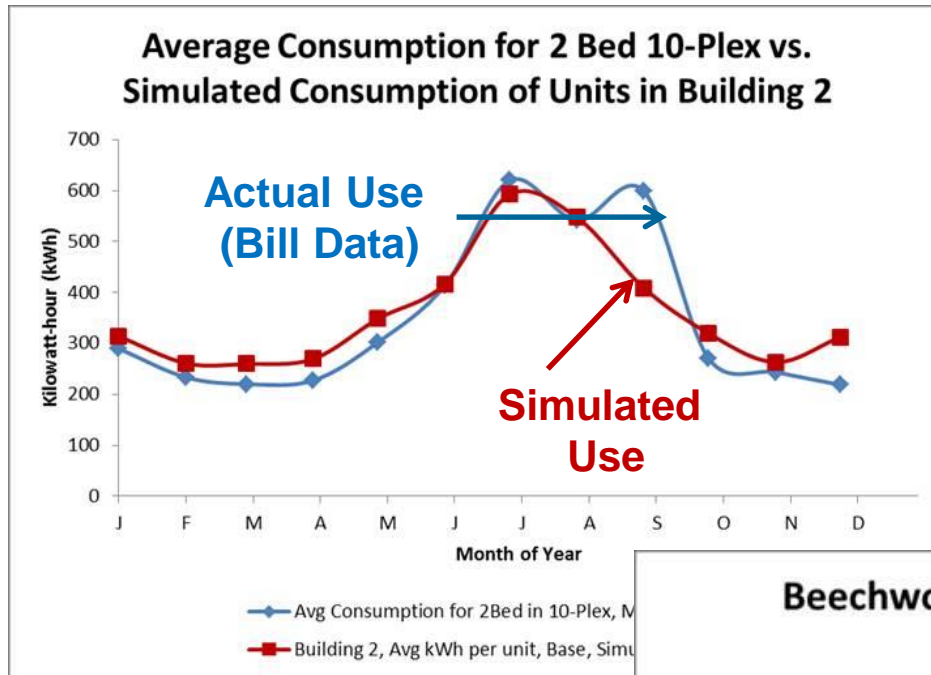
Step 4: Emerging Technologies

- Develop matrix of gas and electric technologies and rank on readiness and impact
- Develop scope of work and implement ET measures
- Install extensive data acquisition and monitor

Step 5: Impact analysis and financial Models

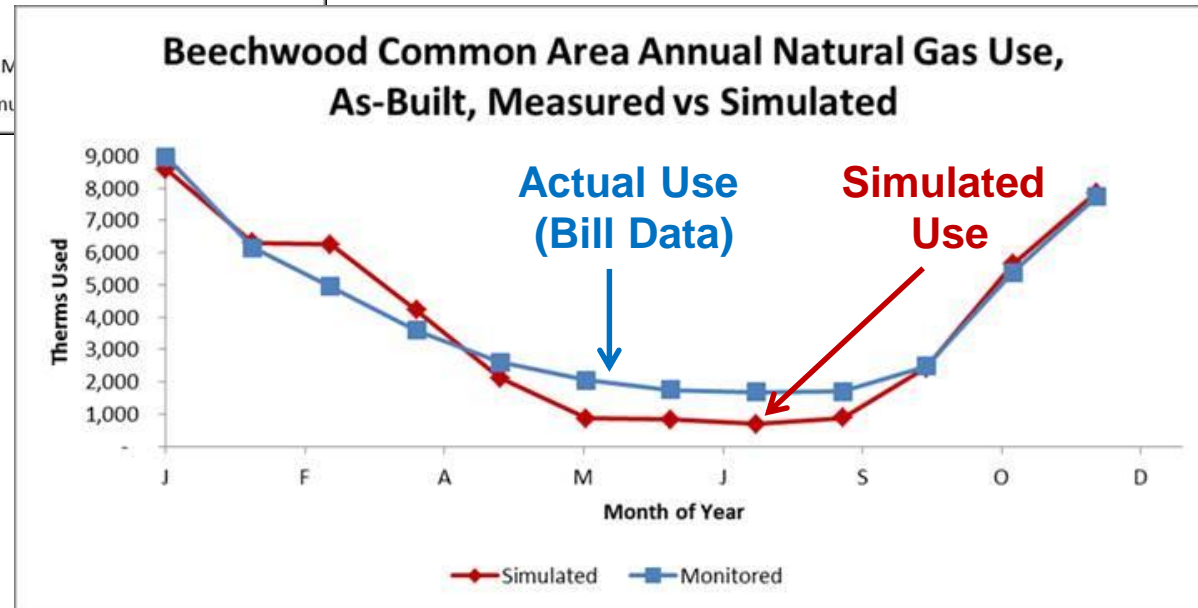
- Evaluate energy impact of technologies
- Track changes in user behavior and re-model buildings
- Develop scaling scenarios with utility OBF, low interest loans and tax credits

Calibrating Building Energy Use



Electric Usage with tenant metering calibrated to 5% annually

Natural Gas Usage with only master metering calibrated to 8% annually



ZNE packages

Category Name	Beechwood 2 Bed Duplex Base Case	ZNE #1 (Re-roof, 8.4 ACH50)	ZNE #2 (No Re-roof, 3 ACH50)	ZNE #3 (Ducts in Conditioned Space)	ZNE #4 (Ducts Sealed, R8 insulation)	ZNE #5 (Ducts Sealed)
	All ZNE Packages Contain the Following Features : Home Energy Management System, EnergySTAR Refrigerator & Dishwasher, Tankless condensing Hot Water Heater (94% EF)					
Operation						
Misc Electric Loads	1273 kWh/yr per unit	1273 kWh/yr per unit, with HEM [5% Savings]	1273 kWh/yr per unit, with HEM [5% Savings]	1273 kWh/yr per unit, with HEM [5% Savings]	1273 kWh/yr per unit, with HEM [5% Savings]	1273 kWh/yr per unit, with HEM [5% Savings]
Walls						
Wood Stud	2" cellulose, Gr-3, 2x4, 16 in o.c.	2" batt, Gr-3, 2x4, 16 in o.c.	2" batt, Gr-3, 2x4, 16 in o.c.	2" batt, Gr-3, 2x4, 16 in o.c.	2" batt, Gr-3, 2x4, 16 in o.c.	2" batt, Gr-3, 2x4, 16 in o.c.
Ceilings/Roofs						
Unfinished Attic	Ceiling, 2" cellulose, R-6.4, gr. 3	Roof R-20	Ceiling, 2" Batt, R-6.4, gr. 3	Ceiling, 2" Batt, R-6.4, gr. 3	Ceiling, 2" Batt, R-6.4, gr. 3	Ceiling, 2" Batt, R-6.4, gr. 3
Roof Material	White or cool colors	White or cool colors	White or cool colors	White or cool colors	White or cool colors	White or cool colors
Radiant Barrier	None	None	None	None	None	None
Windows & Doors						
Windows	0.67 / 0.76	0.67 / 0.76	0.67 / 0.76	0.67 / 0.76	0.67 / 0.76	0.67 / 0.76
Airflow						
Air Leakage	14.1 ACH50	Sealed to 8.5 ACH50	3 ACH50	Sealed to 8.5 ACH50	Sealed to 8.5 ACH50	Sealed to 8.5 ACH50
Major Appliances						
Refrigerator	18 cu ft., EF = 15.9, top freezer	18 cu ft., EF = 21.9, top freezer	18 cu ft., EF = 21.9, top freezer	18 cu ft., EF = 21.9, top freezer	18 cu ft., EF = 21.9, top freezer	18 cu ft., EF = 21.9, top freezer
Dishwasher	318 Annual kWh	290 Annual kWh	290 Annual kWh	290 Annual kWh	290 Annual kWh	290 Annual kWh
Lighting						
Lighting	100% Incadescent	100% LED, Hardwired & Plugin	100% LED, Hardwired & Plugin	100% LED, Hardwired & Plugin	100% LED, Hardwired & Plugin	100% LED, Hardwired & Plugin
Space Conditioning						
Air Conditioner	SEER 13, Roof Mounted	SEER 13, Roof Mounted	SEER 13, Roof Mounted	SEER 13, Roof Mounted	SEER 13, Roof Mounted	SEER 13, Roof Mounted
Furnace	Gas, 80% AFUE	Gas, 80% AFUE	Gas, 80% AFUE	Gas, 80% AFUE	Gas, 80% AFUE	Gas, 80% AFUE
Air Source Heat Pump	None	None	None	None	None	None
Ducts	32% Leakage, Uninsulated	Sealed and encased in insulation	In Finished Space	In Finished Space	Sealed to 7.5% Leakage, R8 insulation	7.5% Duct Leakage, Uninsulated
Water Heating						
Water Heater	Gas, 40gal storage, 0.62 EF	Gas, Tankless condensing, 96% EF	Gas, Tankless condensing, 96% EF	Gas, Tankless condensing, 96% EF	Gas, Tankless condensing, 96% EF	Gas, Tankless condensing, 96% EF
Solar Water Heating	None	56.42 sqft Closed Loop, Jiangsu Sunrain	56.42 sqft Closed Loop, Jiangsu Sunrain	56.42 sqft Closed Loop, Jiangsu Sunrain	56.42 sqft Closed Loop, Jiangsu Sunrain	56.42 sqft Closed Loop, Jiangsu Sunrain

Emerging Technologies – Analyzed and evaluated

Common Area

- 99% Gas Condensing Tankless for laundry
- High Efficiency RTU w/ FDD
- Economizer Retrofit
- Foam roof insulation, cool roof and insulated ducts
- Aerosol Envelope Sealing
- Ozone retrofit kits
- Moisture sensing retrofit for dryers
- LED lighting indoor
- LED outdoor lighting
- HVAC FDD
- Smart Thermostats

Tenant Units (30)

- Solar Thermal Water Heating
- T-stats with EE and DR capability
- Boxing and ducts in semi-insulated spaces
- Air sealing
- Home Energy Management Systems
- Insulated underground piping
- Messaging for behavioral change
- Post-installation surveys
- Non-intrusive load monitoring systems
- Weather stripping
- Refrigerator Replacements
- Outdoor LED lighting
- Indoor LED lighting

Out with the old; In with the new...



Construction Photos (1) – Ducting and Roofing



Stripped
roof on
Bldg 3 for
foaming

New duct
joints



Old
crumpled
ducts



Old and new ductwork



Duct boots sealed

Construction Photos (2) – Solar Thermal and Lighting



New
outdoor
lighting



Solar Thermal tank and hot
water closet



HVAC Data
Monitoring
wireless
enabled



Solar Thermal Heat
Exchanger piping



Solar Thermal on roof

Commissioning and Performance Tests



Test Smart Thermostat



Measure HVAC Leakage, Air Flow



Measure Envelop Leakage



Test District Heating



Test Solar Thermal System



Test Foam Insulation

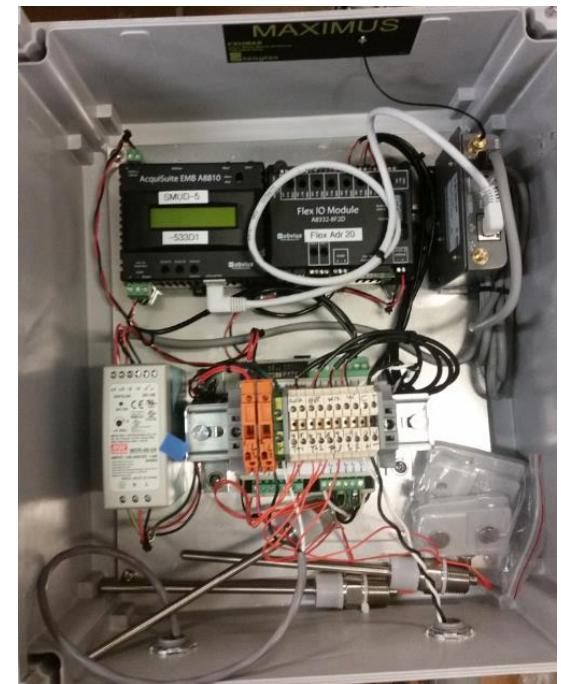
Building Commissioning – Example Worksheet

Basic Information				Envelope Leakage Data (at 50 PA) ¹				Duct Leakage Data (at 25 Pa) ⁴					
(check box for either test in or test out)				Envelope Leakage Test with ducts uncovered (Depressurized)		Envelope Leakage Test with ducts uncovered (Pressurized)		Duct Test with Blower Door Pressurize Apt & Ducts +25 Pa (Registers Covered)			Duct Leakage Test only		
Date of Test	UNIT # (from Front Door)	Test In (✓)	Test Out (✓)	CFM to De-Pressurize Apt to -50 Pa	Picture (✓) ²	CFM to Pressurize Apt to +50 Pa	Picture (✓) ²	CFM (at +25 Pa ¹)	BD Reading @ that time	Picture (✓) ³	CFM (at +25 Pa ¹)	Picture (✓) ²	Comments
7/30/2015	5		✓	821	✓	880	✓	137	600	✓	116	✓	
	7		✓	947	✓	890	✓	198	847	✓	149	✓	
	4		✓	893	✓	979	✓	133	677		88	✓	
	1		✓	746	✓	842	✓	158	587		104	✓	
	19		✓	410	✓	503	✓	161	523		115	✓	
	28		✓	786	✓	842	✓	122	589		87	✓	
	25		✓	627	✓	773	✓	140	522		99	✓	
	26		✓	587	✓	727	✓	140	502	✓	98	✓	
	33	✓		1005 @ 45.6	✓	1134 @ 46.1	✓	249	832		231	✓	
	34	✓		1056 @ 45.3	✓	1107 @ 47.6	✓	307	819		202	✓	
	32	✓		890	✓	985	✓	311	728		205	✓	

Monitoring Plan: HVAC and Electric

Control – Treatment Methodology

One apartment building without EE measures was used as a control
T, RH, V and A are monitored. Thermistors are located at ducts. Clamp-
on CTs & voltage meters for rooftop AC units.



EPRI Data Acquisition Box

Gas Consumption Monitoring Plan

- SCG installed a total of 31 AMI Gas Meters
- 3 main uses – rooftop units, water heaters and laundry

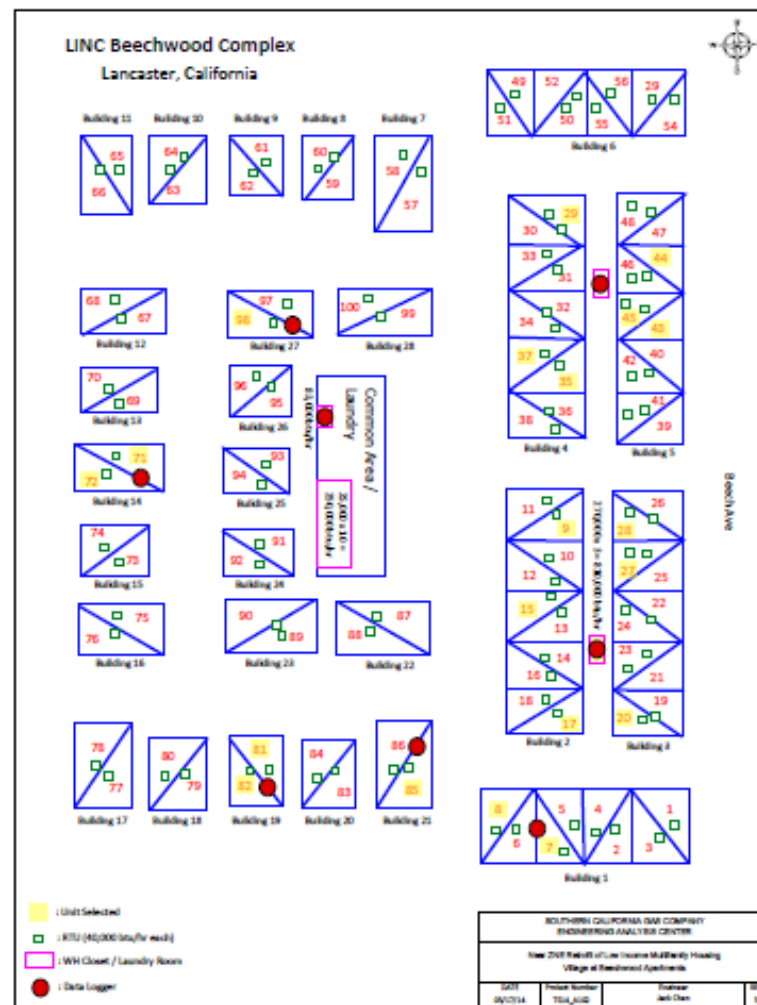


Retrofit

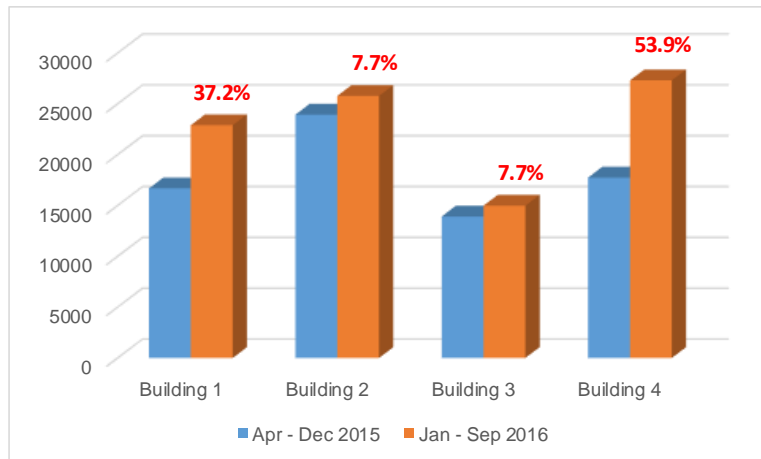
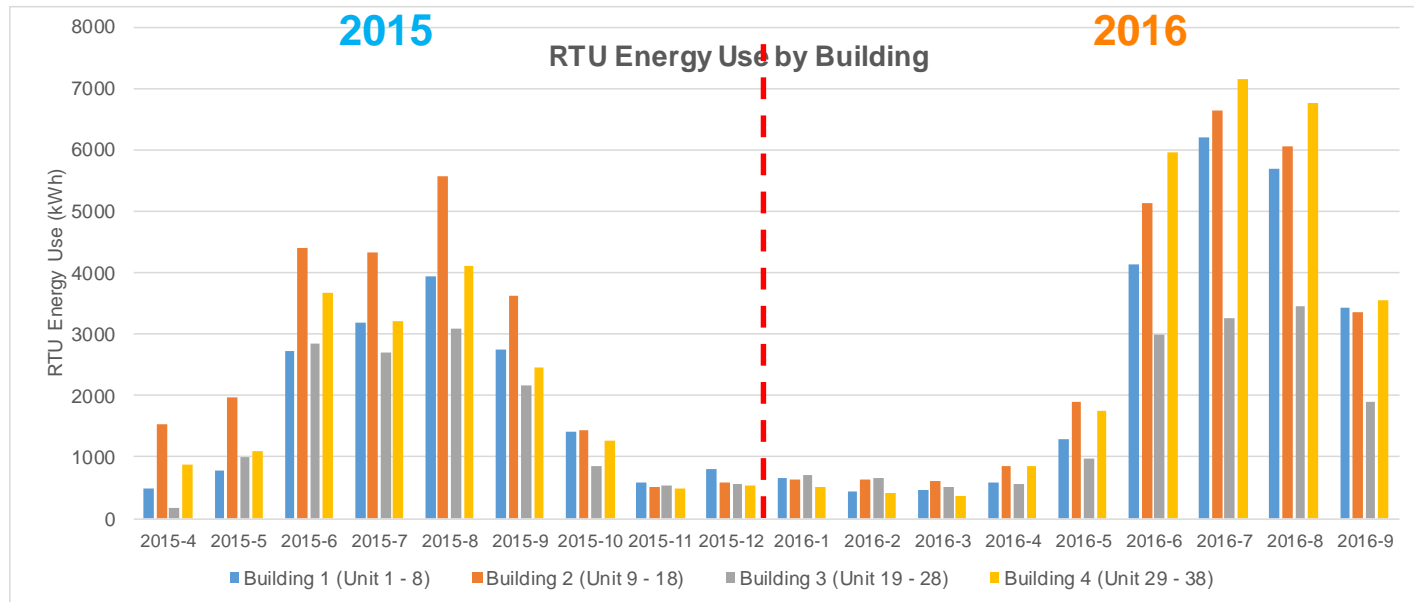
Unit 7 Unit 6 Unit 9 Unit 13 Unit 18 Unit 19 Unit 25 Unit 26

Baseline

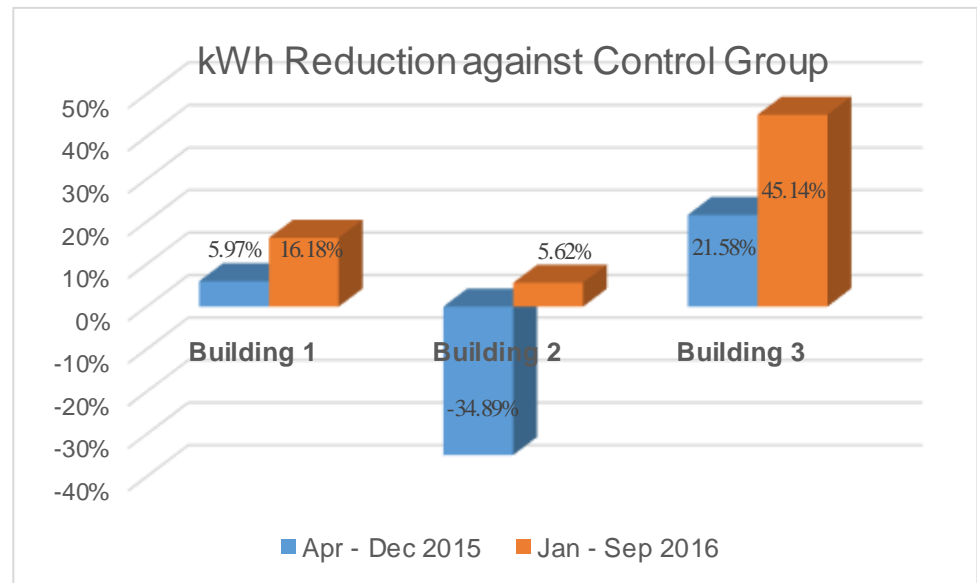
Unit 29 Unit 37 Unit 35 Unit 43 Unit 44 Unit 45 Unit 71 Unit 72 Unit 81 Unit 82 Unit 85 Unit 86 Unit 97 Unit 98 Com Area



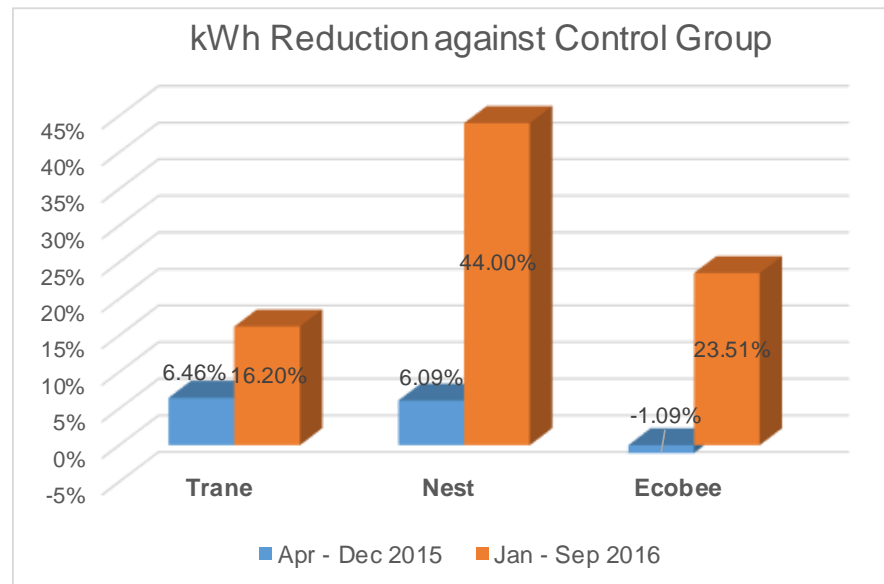
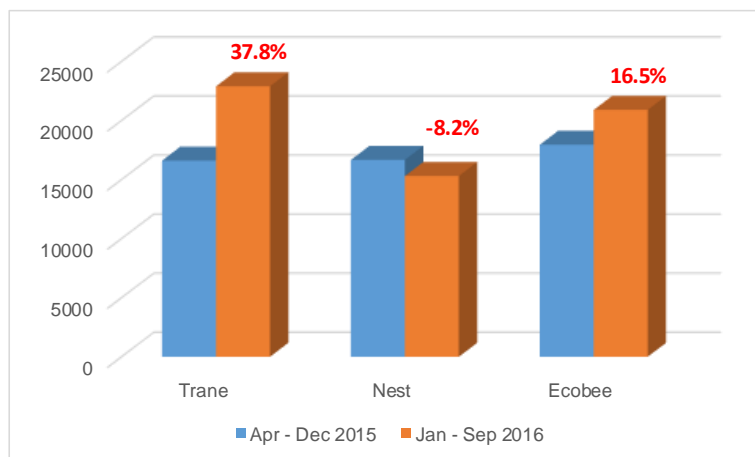
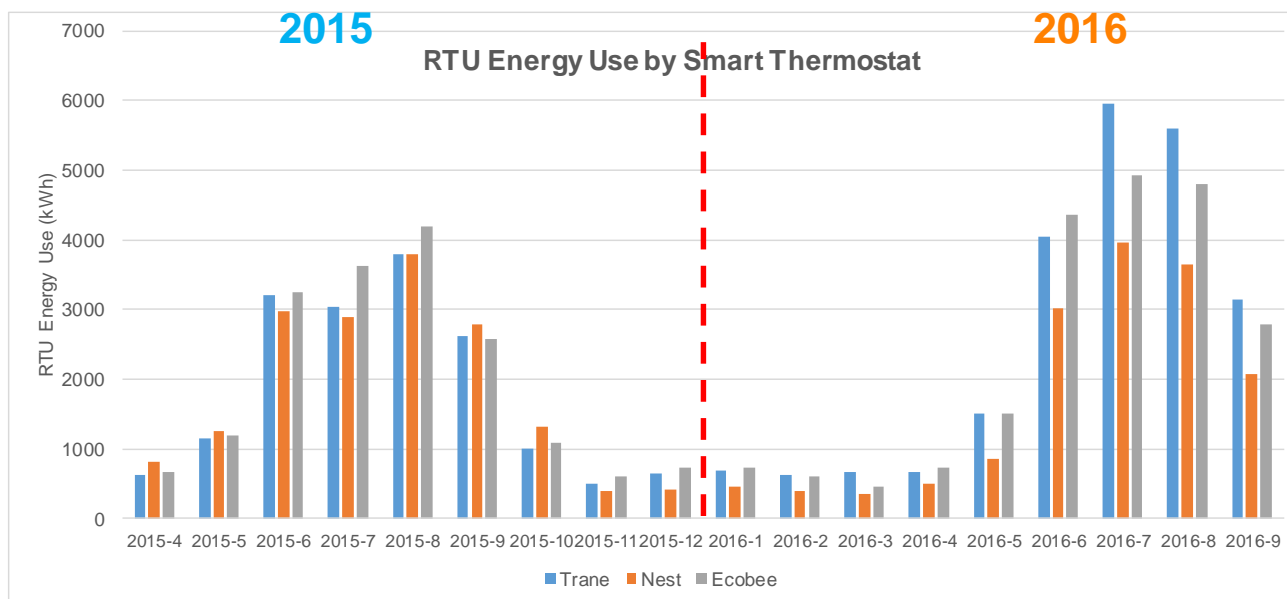
RTU Electric Energy Use Analysis (by buildings)



- kWh increased due to hotter summer in 2016
- kWh increase of Treatment less than Control



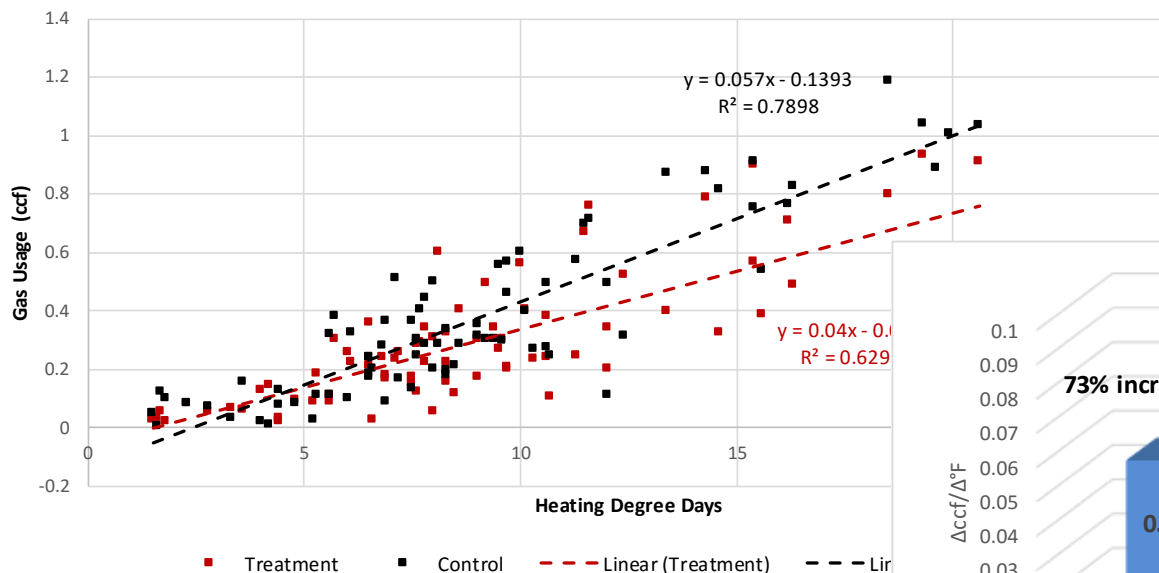
RTU Electric Energy Use Analysis (by thermostat groups)



- Occupants reported Trane's panel was hard to use
- Ecobee and Nest are easier to use

RTU Gas Use Analysis

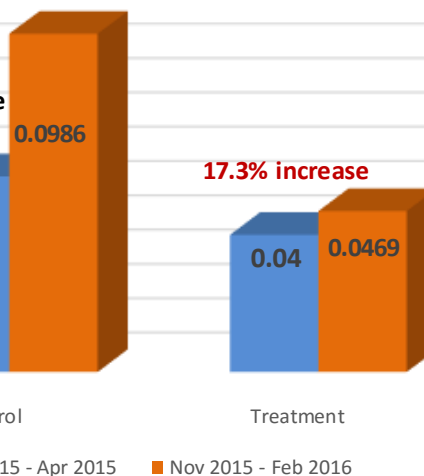
Feb 2015 - Apr 2015



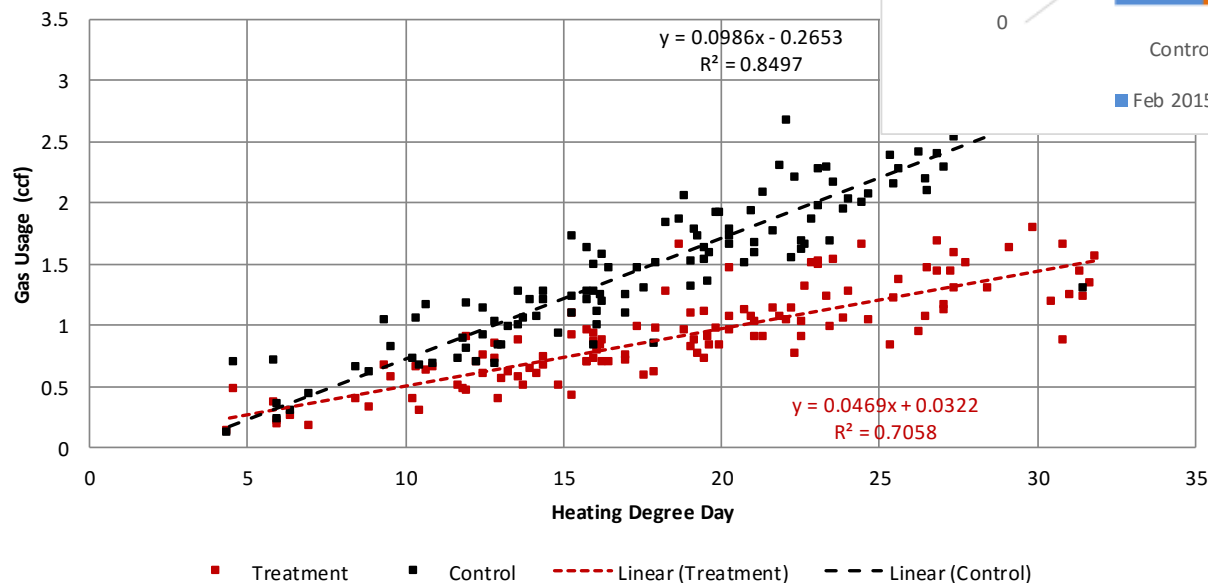
Pre-comparison of Treatment Group vs. Control Group

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73% increase



Nov 2015 - Feb 2016

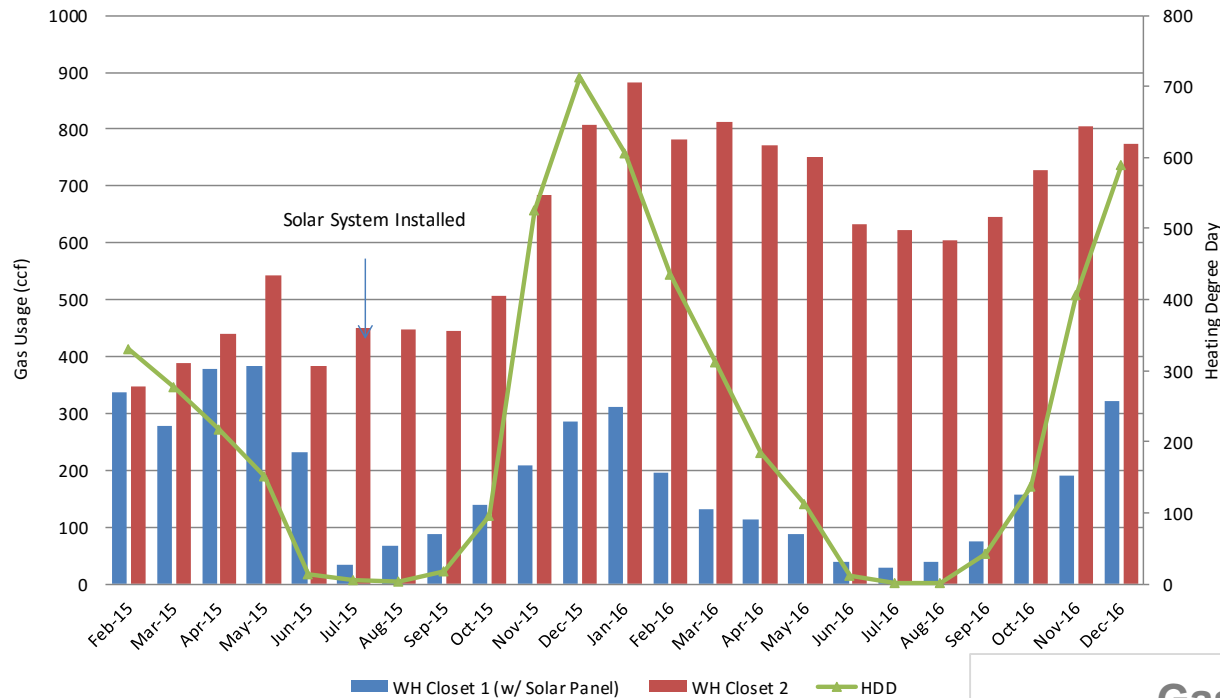


2.1 times more HDD results in 73% more heating in Control vs. 17.3% more heating in Treatment

Post-comparison of Treatment Group vs. Control Group

Solar Thermal System – Significant Gas Use Reduction

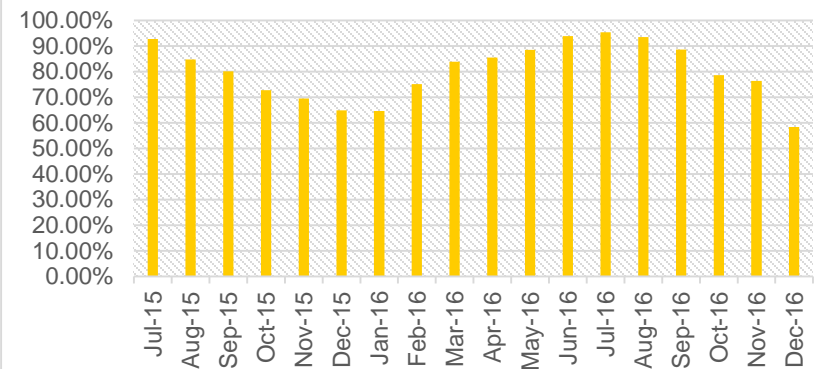
Water Heater Closet Gas Consumption, Monthly



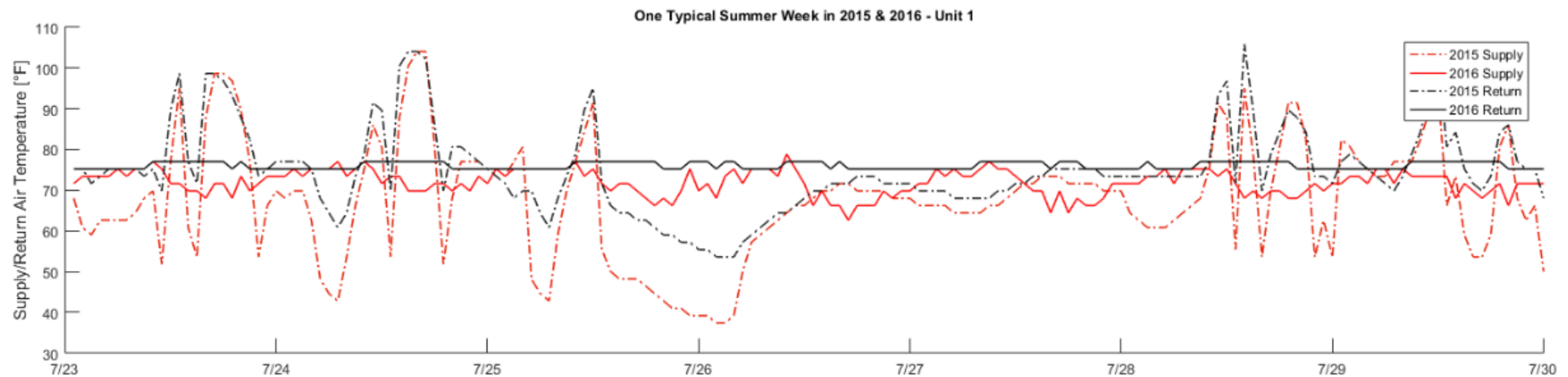
100 gallon water heater closet provides domestic hot water for Building #1, #2 and #3. Solar thermal system is added to provide hot water pre-heating

A mirrored 100 gallon water heater closet provides hot water for Building #4, #5 and #6, and used as the baseline

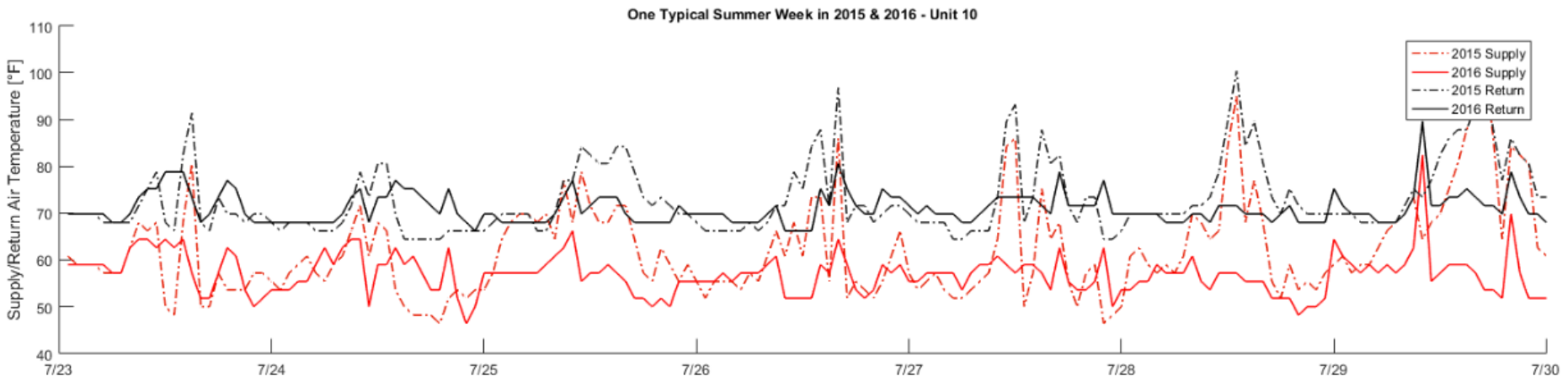
Gas Use Reduction (%)



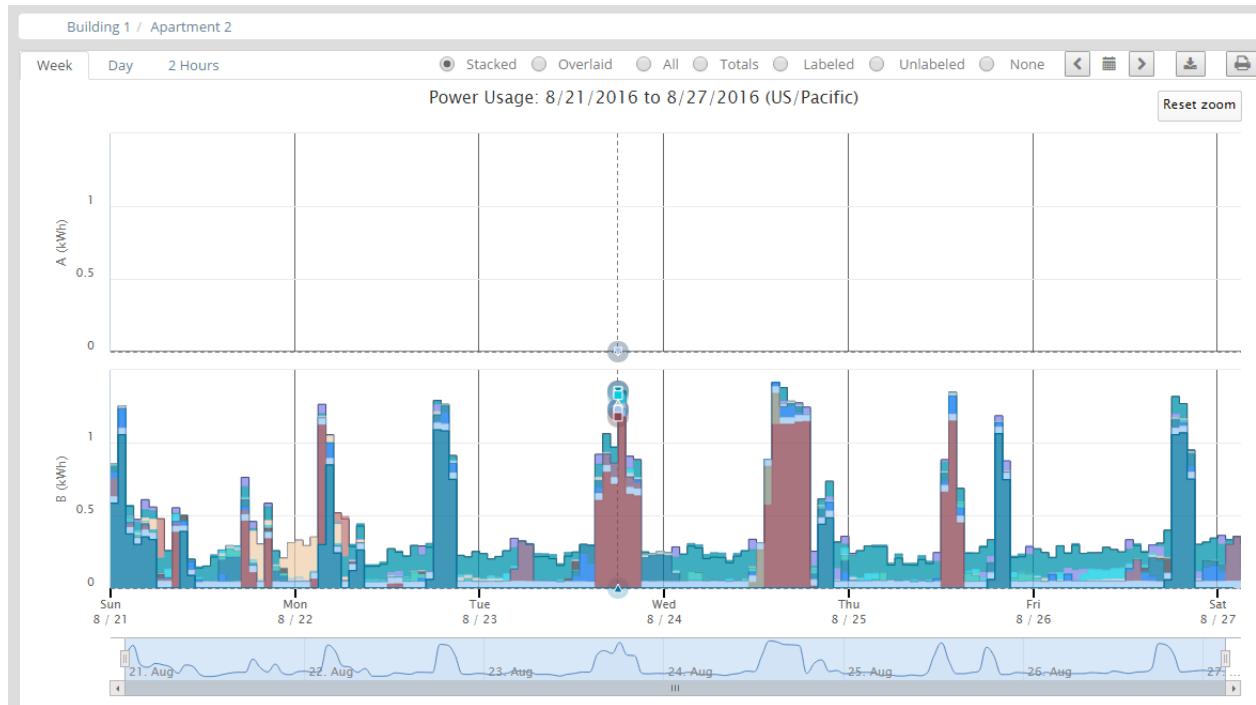
Smart Thermostats – better HVAC operation and comfort



Smart thermostats improved RTU operation from intermittent on/off to more stable and substantially improved comfort with more consistent indoor temperatures

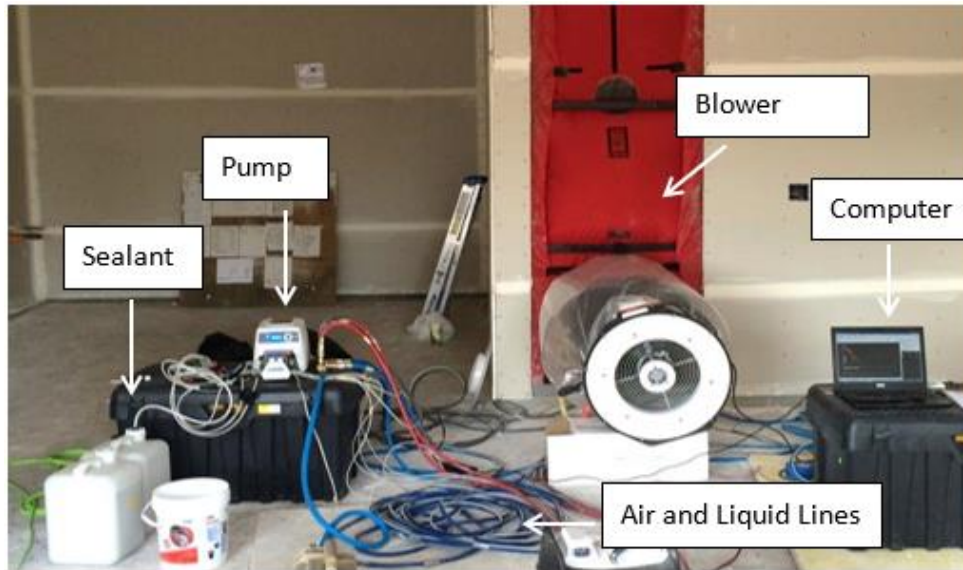


Non-Intrusive Load Monitoring on Building 1

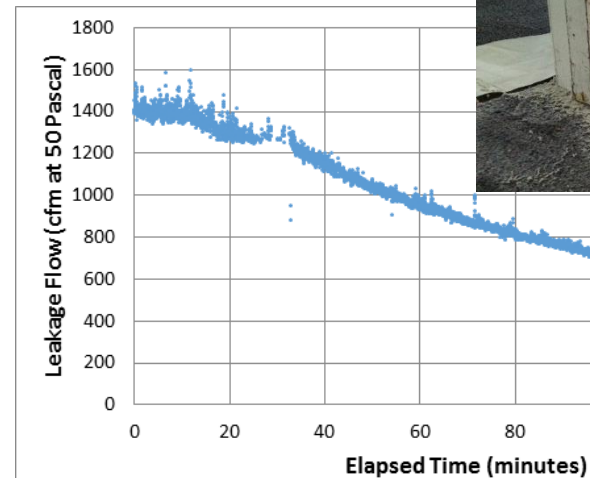


- Total load is disaggregated through an identification process (2 – 3 hrs/unit)
- Major loads (e.g., refrigeration, TV, etc.) can be identified, but not smaller loads
- System installed outside of apartments. Easier maintenance.

Aerosol Envelope Sealing for Common Area



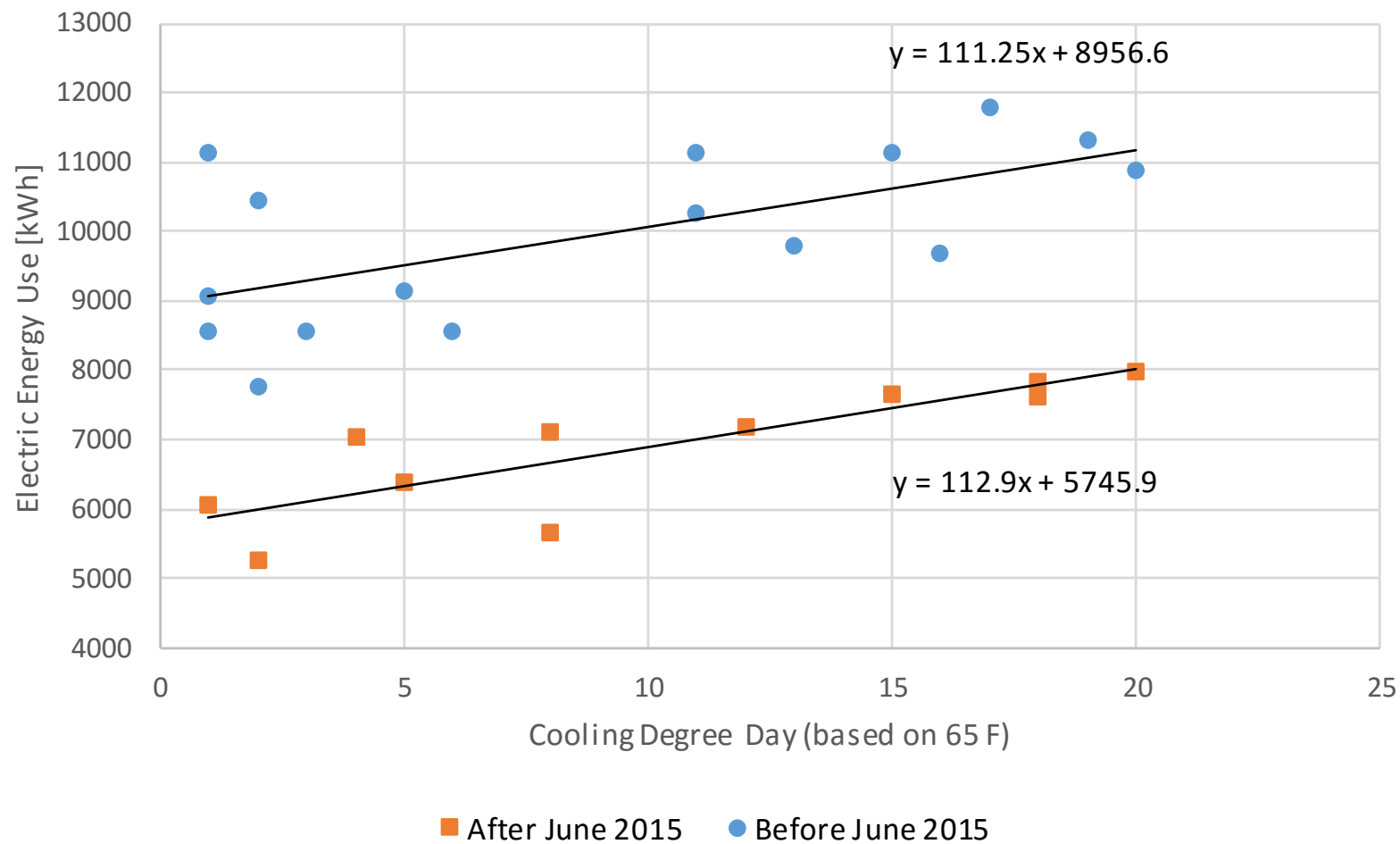
Sealing Profile of Common Area



Extension of Aerosol duct sealing developed by UC Davis

Blower Door Test All tests conducted @ CFM 50 Pascals (+ -)	BASELINE CFM 12/4/14	CFM After Aerosol Seal applied 5/9/16	Incremental CFM Change	% of Original CFM Leakage	Incremental Air Leakage Change	CFM After Foam Roof/Ducts plus Economizers added 10/11/16	Incremental CFM Change	% of original CFM leakage	Incremental Air Leakage Change	Final CFM/ Change from Baseline
Whole Building Test Depressurized CFM -50 Pascals	3,950	3,645	-305	92%	-8%	3,460	-185	88%	-4%	-490
Whole Building Test Pressurized CFM +50 Pascals	4,495	4,010	-485	89%	-11%	3,215	-795	72%	-17%	-1,280

Common Area Electric Energy Use



Estimated Impact of individual measures

Measure	Unit	Modeled (per unit)	Measured (per unit)
Envelope Improvement Package – duct replacements, insulation and semi-conditioned attic, air sealing (electric)	kWh	45% (145 out of 239 Therms)	22% (based on RTU operation)
Envelope Improvement Package – duct replacements, insulation and semi-conditioned attic, air sealing (gas)	Therms	60% (451 out of 753 Therms)	34% (based on RTU usage)
Air sealing ACH improvement	%	Not modeled	30%
Smart Thermostats – average (electric)	kWh	5%	14% (estimated)
Smart Thermostats – Average (gas)	Therms	5%	14% (estimated)
WH Improvements – Solar Thermal	Therms	55% (118 Therms)	70% savings (100 Therms/unit)
WH improvements – distribution improve	Therms	35% (82 Therms)	
LED lighting	kWh	55%	Under calculation
Spray Foam Roof Insulation	kWh	35%	17%

Technology Transfer and Benefits



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Home » Solutions » Implementation Models » Replicable and Scalable Near-Zero Net Energy Retrofits for Low-Income Housing

ORGANIZATION TYPE

Affordable housing developer

BARRIER

Obtaining financing for near-zero net energy retrofits in low-income housing

SOLUTION

Developed the replicable and scalable near-zero net energy retrofit model

OUTCOME

Creation of a model that documents the steps low-income multifamily property owners can take to make whole-building energy efficiency retrofits

Implementation Model:

Replicable and Scalable Near-Zero Net Energy Retrofits for Low-Income Housing

OVERVIEW

LINC Housing has over 30 years of experience creating communities for limited income families, seniors, and persons with special needs throughout California. LINC is committed to building housing that is affordable, environmentally sustainable, and a catalyst for community improvement. LINC communities are known for excellent design, outstanding management, and life-enhancing resident services.

[More](#)



Better Buildings
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.@LINChousing's #zeroenergy housing for low income communities. #BetterBuildings Beat Blog: 1.usa.gov/1U0Z4V4



- Final Report draft being reviewed
- Project presentation March 28

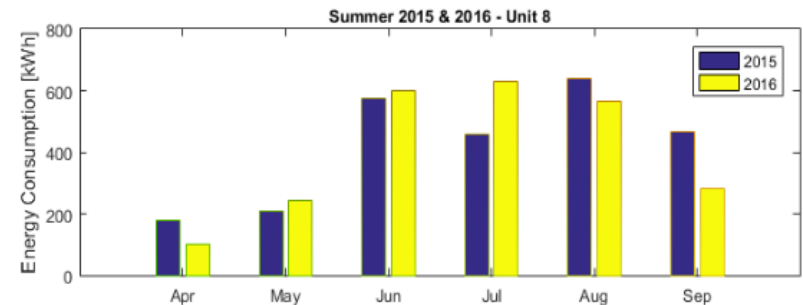
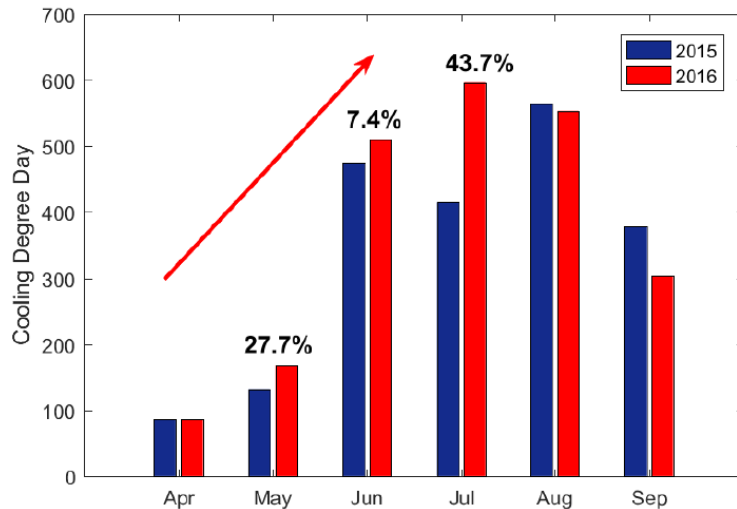
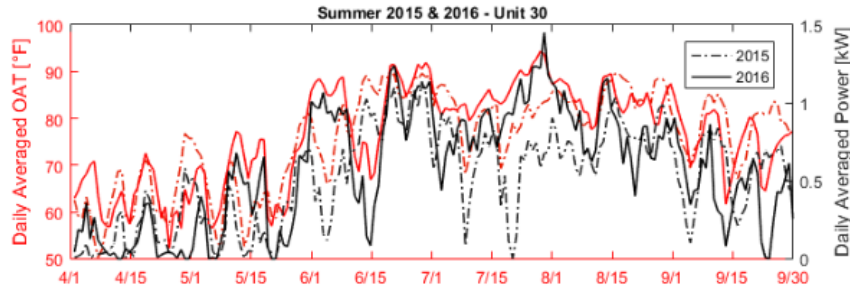
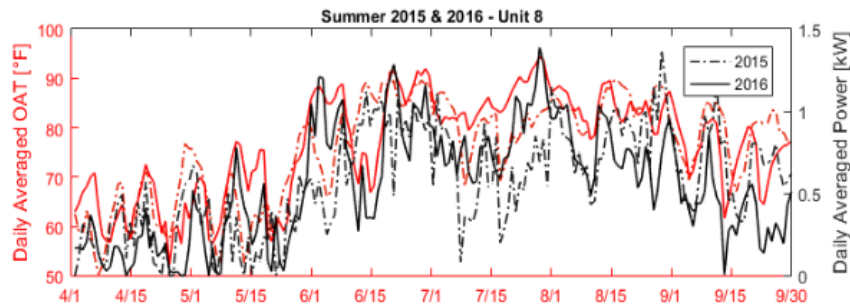


Together...Shaping the Future of Electricity

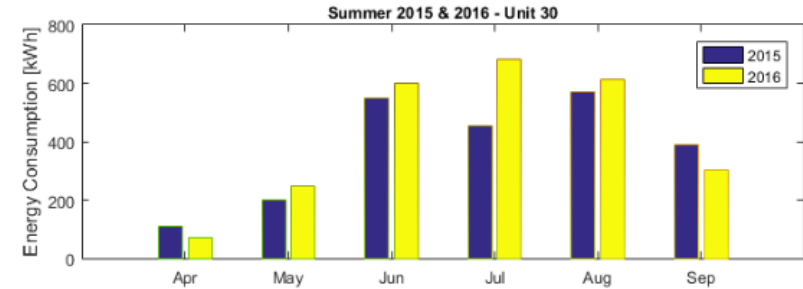
Low Income challenges

- High occupant turnover
- Energy is low on list of priorities
- Lack of education and awareness
- Occupancy patterns
- Lack of internet connectivity
 - Left out of tools and new applications

Power Consumption of RTU of Apartment Units



Treatment



Control

Post-data is collected from a hot summer (2016) to be compared against the pre-data from a normal summer (2015)

Test-in & Test-Out Results (Day 2)

Basic Information				Envelope Leakage Data (at 50 Pa) ¹				Duct Leakage Data (at 25 Pa) ⁴					
(check box for either test in or test out)				Envelope Leakage Test with ducts uncovered (Depressurized)		Envelope Leakage Test with ducts uncovered (Pressurized)		Duct Test with Blower Door Pressurize Apt & Ducts +25 Pa (Registers Covered)			Duct Leakage Test only		
Date of Test	UNIT # (from Front Door)	Test In (✓)	Test Out (✓)	CFM to De-Pressurize Apt to -50 Pa	Picture (✓) ²	CFM to Pressurize Apt to +50 Pa	Picture (✓) ²	CFM (at +25 Pa ¹)	BD Reading @ that time	Picture (✓) ³	CFM (at +25 Pa ¹)	Picture (✓) ²	Comments
7/30/2015	5		✓	821	✓	880	✓	137	600	✓	116	✓	
	7		✓	947	✓	890	✓	198	847	✓	149	✓	
	4		✓	893	✓	979	✓	133	677		88	✓	
	1		✓	746	✓	842	✓	158	587		104	✓	
	19		✓	410	✓	503	✓	161	523		115	✓	
	28		✓	786	✓	842	✓	122	589		87	✓	
	25		✓	627	✓	773	✓	140	522		99	✓	
	26		✓	587	✓	727	✓	140	502	✓	98	✓	
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	34	✓		1056 @ 45.3	✓	1107 @ 47.6	✓	307	819		202	✓	
	32	✓		890	✓	985	✓	311	728		205	✓	

Test In and Out Results (Day 3)

Basic Information				Envelope Leakage Data (at 50 Pa) ¹				Duct Leakage Data (at 25 Pa) ⁴					
(check box for either test in or test out)				Envelope Leakage Test with ducts uncovered (Depressurized)		Envelope Leakage Test with ducts uncovered (Pressurized)		Duct Test with Blower Door Pressurize Apt & Ducts +25 Pa (Registers Covered)			Duct Leakage Test only		
Date of Test	UNIT # (from Front Door)	Test In (✓)	Test Out (✓)	CFM to De-Pressurize Apt to -50 Pa	Picture (✓) ²	CFM to Pressurize Apt to +50 Pa	Picture (✓) ²	CFM (at +25 Pa ¹)	BD Reading @ that time	Picture (✓) ³	CFM (at +25 Pa ¹)	Picture (✓) ²	Comments
7/31/2015	31	✓		1045 - Ring 1	✓	1608 - Ring 1	✓	346	1190		233	✓	
	35	✓		895	✓	1480 - Ring 1	✓	226	1070		189	✓	
	37	✓		955	✓	1023	✓	230	792		158	✓	
	29	✓		980	✓	1004	✓	318	928		328		
	30	✓		1115	✓	1680	✓	293	1223	✓	211	✓	
	18		✓	908	✓	940	✓	183	739	✓	108	✓	Large opening @ roof access
Notes:													
1. Blower Door pressure and depressure to 50 Pascals (Pa)													
2. One Picture for each of 4 tests: Blower-Door, both pressurized and depressurized, and two for Duct Blaster, with and without Blower Door; take as follows:													
Picture Monometer in front showing reading, with setup in background to show blower-door and/or duct-blaster setup;													
3. For simultaneous duct-blaster and blower-door, two pictures may be needed, one of duct reading and setup, one of blower-door reading and setup.													
4. 25 Pascals (Pa) for all duct-blaster tests, both simultaneous with Blower-Door, with Blower Door at 25 Pa, and Duct-Blaster alone.													

Test In & Test Out Results (Day 1)

Beechwood Manor Retrofit Test Results

Note that **the sequence of tests is important**: The Blower-Door should be done first, with the registers uncovered. The **Duct Blaster** should not be set up, including sealing the registers, until after the **Envelope Leakage** tests (both pressurized and de-pressurized Blower-Door tests) have been completed.

Basic Information				Blower Door				Blower-Door and Duct Blaster Together			Duct-Blaster Only		
(check box for either test in or test out)				Envelope Leakage Data (at 50 PA) ¹				Duct Leakage Data (at 25 Pa) ⁴					
				Envelope Leakage Test with ducts uncovered (Depressurized)		Envelope Leakage Test with ducts uncovered (Pressurized)		Duct Test with Blower Door Pressurize Apt & Ducts +25 Pa (Registers Covered)			Duct Leakage Test only		
Date of Test	UNIT # (from Front Door)	Test In (✓)	Test Out (✓)	CFM to De-Pressurize Apt to -50 Pa	Picture (✓) ²	CFM to Pressurize Apt to +50 Pa	Picture (✓) ²	CFM (at +25 Pa ¹)	BD Reading @ that time	Picture (✓) ³	CFM (at +25 Pa ¹)	Picture (✓) ²	Comments
7/29/2015	10		✓	799	✓	995	✓	194	626	✓	134	✓	
	12		✓	718	✓	902	✓	170	702	✓	122	✓	
	9		✓	855	✓	961	✓	216	660	✓	158	✓	
	36	✓		1010	✓	1058	✓	324	980	✓	211	✓	
	38	✓		971	✓	1021	✓	310	773	✓	230	✓	
	15		✓	811	✓	984	✓	175	710	✓	114	✓	
	14		✓	760	✓	966	✓	229	679	✓	156	✓	
	84		✓	1028	✓	1068	✓	157	778	✓	106	✓	Large opening @ roof access

Summary of energy savings by unit

			Base Case						VERS Case, opt 1						
			Utility Bill Data	BEopt v2.3.0.1 Models											
Building #	Apt #s	Total # of Units	kWh used per unit		kWh per 2 units	% Difference from Bill Data, per unit	Therms per year, Per unit	Therms per year, Per 2 units	kWh used per yr, per unit	% kWh Savings per unit	kWh per 2 units	Therms per year, Per unit	Therms per year, Per 2 units	% therms saved per unit	
1	1,3	2	4,939	4,445	8,889	-10%	354	708	3,615	19%	7,230	123	246	65%	
1	2,4	2	4,939	4,637	9,274	-6%	309	618	3,641	21%	7,282	104	207	66%	
1	3,7	2	4,939	4,637	9,274	-6%	309	618	3,641	21%	7,282	104	207	66%	
1	4,8	2	4,939	4,455	8,910	-10%	362	724	3,618	19%	7,236	128	255	65%	
2	9, 11	2	4,438	4,439	8,878	0.02%	362	723	3,721	16%	7,442	153	306	58%	
2	10, 12	2	4,438	4,708	9,416	6%	309	618	3,763	20%	7,527	126	251	59%	
2	13, 14	2	4,438	4,910	9,819	11%	256	513	3,764	23%	7,529	126	251	51%	
2	15, 17	2	4,438	4,708	9,416	6%	309	618	3,763	20%	7,527	126	251	59%	
2	16, 18	2	4,438	4,466	8,932	1%	347	695	3,641	18%	7,283	123	246	65%	
3	19, 21	2	3,908	3,897	7,793	-0.3%	314	628	3,205	18%	6,410	114	227	64%	
3	20, 22	2	3,908	3,887	7,773	-1%	287	574	3,186	18%	6,372	93	186	68%	
3	23, 25	2	3,908	3,887	7,773	-1%	287	575	3,187	18%	6,375	93	186	68%	
3	24, 26	2	3,908	3,887	7,773	-1%	287	574	3,186	18%	6,372	93	186	68%	
3	26, 28	2	3,908	3,915	7,829	0.2%	302	604	3,295	16%	6,589	105	209	65%	
20	80, 81	2	4,632	4,487	8973	-3%	318	636	3,589	20%	7,178	185	371	42%	
21	85	1	7,237	7251	n/a	0.2%	466	n/a	4,839	33%	n/a	288	n/a	38%	
21	86	1	7,237	7153	n/a	-1%	514	n/a	4434	38%	n/a	310	n/a	40%	
avg, per unit						-0.9%									

Community Center Savings

Beechwood Community Center in CBECC (ducts outside)		Hybrid CBECCC and BEopt	Beechwood Community Center in BEopt v2.3						
	Base Case	Base CC Total (estimated CBECC & BEopt)	ZNE #2 (Common Area)	ZNE #2 (Laundry room, El. dryers)	ZNE #2 (Laundry room, gas dryers)	ZNE #2 Outdoor Lighting (LED)	ZNE Community Center, Total (estimated)	% Savings, estimated	\$Saved per year
Spc Heat	679	2,979	-	299	299	-	299	90%	\$ 430
Spc Cool	5,027	6,836	3,127	372	372	-	3,499	49%	\$ 535
IAQ Vent	94	291	698	164	164	-	862	-196%	\$ (92)
Ins Light	1,506	17,500	1,483	264	264	5,220	6,967	60%	\$ 1,690
Appl & Cook	759	1,483	847	7,330	645	-	1,492	-1%	\$ (1)
Plug Lds	2,694	1,600	1,600	-	-	-	1,600	0%	\$ 0
TOTAL	10,759	29,852	7,755	8,429	1,744	5,220	14,718	51%	\$ 2,427
% Error	-71%	-19%							
Spc Heat	772	1,197	649	-	-	-	649	46%	\$ 505
Wtr Heat	176	221	63	19	19	-	82	63%	\$ 128
Appl & Cook	21	206	19	-	188	-	207	-1%	\$ (1)
TOTAL	969	1,538	731	19	207	-	938	39%	\$ 552
Annual Savings									\$ 2,980
\$ 0.16	/kWh								
\$ 0.92	/Therm								

Impact of individual measures

Measure	Unit	Modeled (per unit)	Measured (per unit)
Envelope Improvement Package – duct replacements, insulation and semi-conditioned attic, air sealing (electric)	kWh	45% (145 out of 239 Therms)	22% (based on RTU operation)
Envelope Improvement Package – duct replacements, insulation and semi-conditioned attic, air sealing (gas)	Therms	60% (451 out of 753 Therms)	34% (based on RTU usage)
Air sealing ACH improvement	%	Not modeled	30%
Smart Thermostats – average (electric)	kWh	5%	14% (estimated)
Smart Thermostats – Average (gas)	Therms	5%	14% (estimated)
WH Improvements – Solar Thermal	Therms	55% (118 Therms)	70% savings (100 Therms/unit)
WH improvements – distribution improve	Therms	35% (82 Therms)	
LED lighting	kWh	55%	Under calculation
Spray Foam Roof Insulation	kWh	35%	17%



Together...Shaping the Future of Electricity

List of ET measures

Common Area

- Gas Condensing Tankless for laundry
- High Efficiency RTU w/ FDD (and variable speed indoor fans)
- Foam roof insulation, cool roof and insulated ducts (existing roof removed)
- **Aerosol Envelope Sealing**
- Ozone retrofit kits (cold water)
- **Moisture sensing retrofit for dryers**
- **LED bi-level?**
- **Weather bug testing?**

Tenant Units (30)

- Non-intrusive load monitoring systems (check Belkin)
- **T-stats with EE and DR capability**
- **Solar Thermal (evac tubes?)**
- **Boxing and ducts in semi-insulated spaces**
- **Home Energy Management Systems (wireless access)**
- **Insulated underground piping**
- **Messaging for behavioral change**
- **Post-installation surveys**

Tenant Units (Duplex)

- Retrofit Rooftop unit with economizer control
- Navien 99% gas tankless water heaters
- On-demand recirc
- **Pilot less range**
- Shower Start (City Gardens) – customer experience
- Mini splits w/ DR
 - 3 options – backup wall furnace, condensing gas backup

Emerging Technologies under consideration

■ HVAC and Water Heating

- Ductless space and water heating with condensing boilers
- High efficiency gas heat pumps for central water heating
- Adsorption water heating
- High efficiency rooftops

■ Energy Management systems

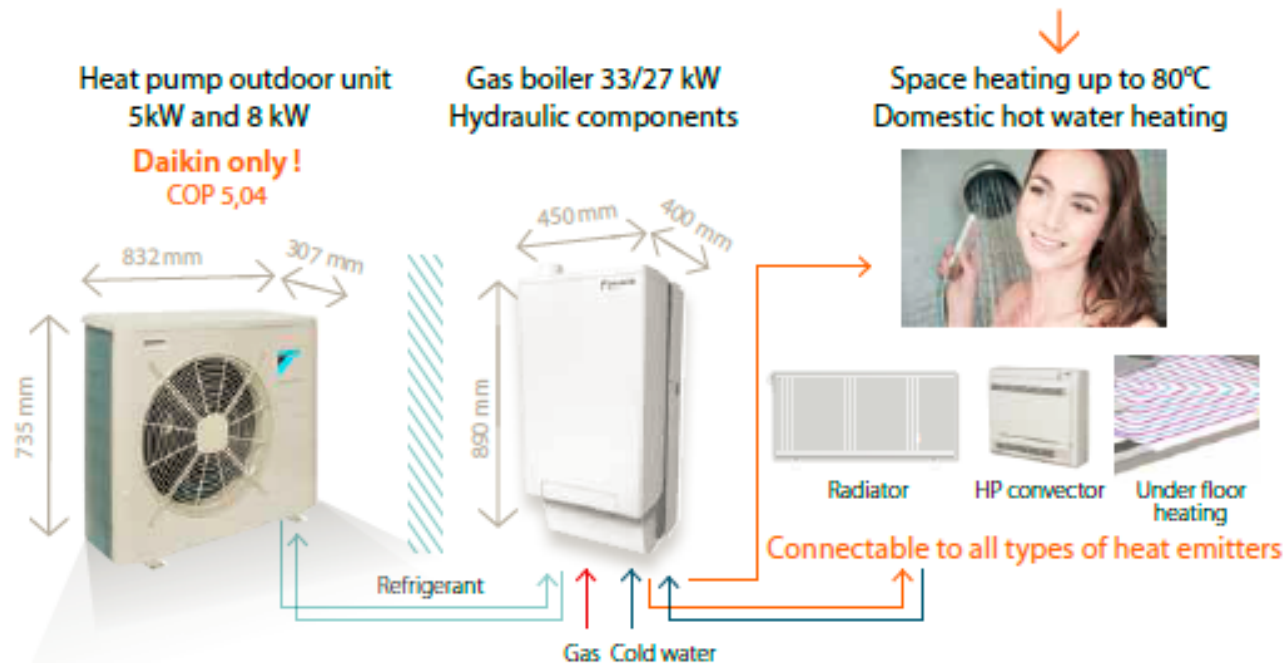
■ Wifi thermostats to optimize heating setpoints and reduce gas usage

■ Solar Thermal



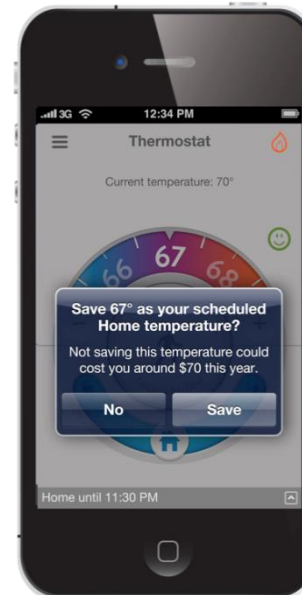
Ductless HVAC with condensing boiler

- Leaky Ducts in unconditioned space are a major source of efficiency losses
- Difficult to put ducts in conditioned space in retrofits
- Ductless systems could provide substantial efficiency improvement



Smart Thermostats

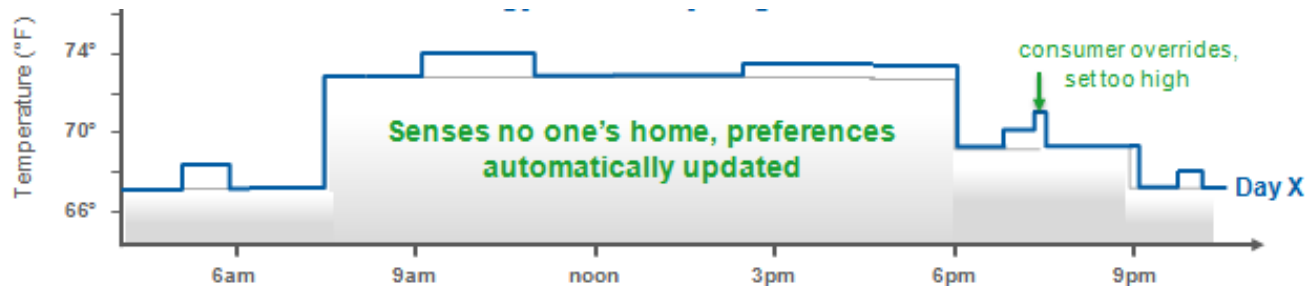
- HVAC usage larger % of usage in low income homes
- Lack of broadband to access latest tools
- Investigating local wifi through cellular



Default behavior for load management

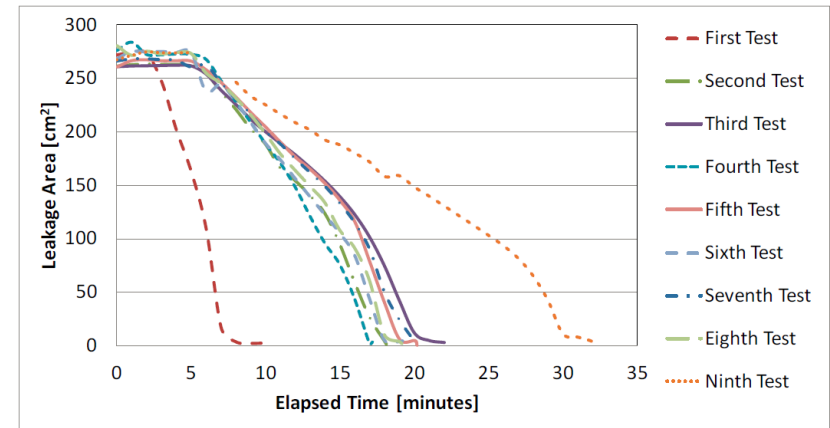


Consumers optimize energy efficiency

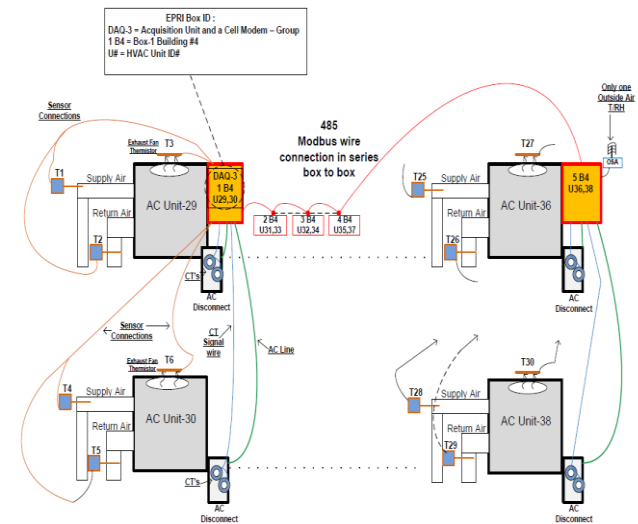


Aerosol envelope sealing

- Extension of Aerosol duct sealing developed by UC Davis
- NYC new construction tests completed



Data Acquisition System



AcquiSuite Data Acquisition Block



Power Supply



Flex IO Module for T, RH data



Power Transducer for power data